

## **TRANSITION FROM FOSSIL FUELS TO RENEWABLE ENERGY: APPLICATION OF OCEAN ENERGY TO POWER ELECTRICAL GRID IN SARAWAK, MALAYSIA.**

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### **Abstract**

Oceans cover more than 70% of the earth's surface. Therefore, the mechanical energy from the tides and waves is one of the most exciting areas of untapped energy potential. Application of ocean energy complements the fossil energy to power an electrical grid. The objective of this study was to investigate how the ocean energy could be applied as one of the main sources to power an electrical grid. Sarawak has been selected as a location to generate ocean energy because the geographical advantage of South China Sea and its wide-opening. A mixed method was utilized comprised a survey among the residents of Sarawak and a case study in High Institutions to understand the technical feasibility of this ocean technology. Ocean energy was found to have an enormous potential to generate energy to power the electrical grid in Sarawak. This technology could be introduced to Kuching, Sarawak to reduce the use of fossil as a source of electricity generation.

**Keywords:** *Ocean energy, Renewable energy, Electrical grid, Ocean energy harvest, Fossil energy*

### **1.0 Introduction**

Ocean energy is one of the renewable energies that have potential to power an electrical grid. The ocean waves are caused by the wind as it blows across the sea. Waves are a powerful source of energy. The purpose of ocean energy is emphasized in this study because the application of ocean energy complements the fossil energy to power an electrical grid. The ocean covers more than 70% the surface of the earth. Thus, it is logical to develop ocean energy. Sarawak has been selected as a location to generate ocean energy because the geographical advantage of the South China Sea and its wide-opening.

The European Union has initially developed ocean energy. According to Anon (2011), renewable energy scenario raised the interest in large scale energy production from waves during the oil crisis of 1973. Then, European Union started to develop the prototype of device to generate energy from wave. The prototype was also constructed in Japan and India.

### **1.1 Research questions**

Thus far, fossil has been used frequently and it will eventually diminish. To overcome this problem before any emerging crisis, many types of renewable energy have been developed such as ocean energy. Ocean energy can replace fossil as a new source of electricity in the future. Thus, the research questions which are pertinent to this matter are;

- How to generate power from the ocean energy?
- What are the encouraging factors for ocean energy adoption?
- What are the innovation solutions to overcome the weaknesses of ocean energy?

## **1.2 Research objectives**

The research objectives of this study were:

- To identify the technical factors and social response at high institution and the people of Sarawak towards ocean energy.
- To investigate important elements in implementing ocean energy.
- To suggest an innovative solution to overcome the weaknesses of ocean energy and enable its implementation.

## **1.3 Research location**

Sarawak was the main location in this research because its location at the South China Sea enabled massive wind which caused huge waves in the ocean. This scenario eased an implementation of the ocean energy in Sarawak. The study was conducted along the beaches of Sarawak.

A higher institution of learning focusing on technical engineering and Electric Engineering in Melaka was chosen to gain more data on ocean energy. Interview sessions were held with the experts of the institution so they can provide comprehensive information on electricity and how to power electricity grid. In short, this Institution was chosen to ease the data access on the technical information and to save cost.

## **2.0 Literature review**

### **2.1 Ocean Energy vs. Fossil Fuels Analysis**

Oil from fossil is commonly used nowadays to generate electricity. However, fossil will end up one day and a source of electricity that is generated from ocean wave energy could be replaced to generate the electricity. Across the globe, evidence is mounting that the production of conventional petroleum will soon reach its peak (Pieprzyk et al. 2009). This section covers the applications, impacts to the environment and productivity of the ocean energy and fossil fuels. On the other hand, the researcher includes the impacts to environment and productivity of the ocean energy and fossil fuels into the technical criteria parameter.

Most villages in Sarawak have insufficient electricity supply. Hence, ocean energy is deemed appropriate to replace fossil as an alternative energy in the Sarawak coastal area.

### **2.2 Technical Criteria**

This section compares the technical criteria of both fossil fuels and ocean wave energy based on three factors; application, productivity and impact to environment (Beggs, 2009; Coley, 2008; Kolliatsas et al., 2012).

**Table 1:** The comparison of technical criteria between ocean wave energy and fossil fuel.

Factors	Ocean Wave Energy	Fossil Fuels
Application	<ul style="list-style-type: none"> <li>• Need to develop a device.</li> <li>• Suitability of place.</li> <li>• Criteria of wave</li> </ul>	<ul style="list-style-type: none"> <li>• Insufficient of fossil place.</li> <li>• Need to dig in the ocean.</li> </ul>
Productivity	<ul style="list-style-type: none"> <li>• Can produce energy as long as the ocean has a sufficient crest of a wave.</li> </ul>	<ul style="list-style-type: none"> <li>• Can produce energy before it is finished.</li> <li>• Need to find another source of fossil after the finish.</li> </ul>
Impact to Environment	<ul style="list-style-type: none"> <li>• Safety, health and safety, environmental and other sea users' considerations.</li> <li>• More alternative to electricity energy.</li> </ul>	<ul style="list-style-type: none"> <li>• Generate pollution.</li> <li>• Increasing the petroleum will lead to increasing of the subsistence.</li> <li>• Helping to reduce erosion of the landscape.</li> </ul>

### 2.3 Environmental Factors

These environmental factors were based on the implication of PESTLE analysis.. PESTLE is an analysis about political, economic, social, technology, legal and environment of the ocean wave energy.

**Table 1.1 :** The PESTLE analysis.

Factors	Sub-factors
<p>Political</p> <p>(Politic generally applied to the art or science of organized government or state, including behavior within civil government)</p>	<ul style="list-style-type: none"> <li>• Malaysia provides National Renewable Energy Policy and Action Plan (2009)</li> <li>• The vision of this policy is enhancing the utilization of indigenous renewable energy resources to contribute towards national electricity supply security and sustainable socioeconomic development.</li> <li>• The objectives: <ul style="list-style-type: none"> <li>- To increase the RE contribution in the national power generation mix.</li> <li>- To facilitate the growth of the RE industry.</li> <li>- To ensure reasonable RE generation costs.</li> <li>- To conserve the environment for future generation</li> <li>- To enhance awareness of the role and importance of RE.</li> </ul> </li> </ul>
<p>Environmental</p> <p>(Environmental is about the circumstances, objects, or conditions by which one is surrounded)</p>	<ul style="list-style-type: none"> <li>• The device will harm the area of the device only.</li> <li>• Less pollution rather than fossil fuels.</li> <li>• The device will disturb the ecosystem nearby.</li> </ul>

<p>Sociological</p> <p>(Refer to a characteristic of living organisms as applied to population of humans and animals.)</p>	<ul style="list-style-type: none"> <li>• According to insufficient electricity supply, residents will be accepted this ocean wave energy to ease their life.</li> </ul>
<p>Technological</p> <p>(Refer to result from improving in technical process that increase productivity of machines and eliminates manual operations or operations done by older machines.)</p>	<ul style="list-style-type: none"> <li>• Ocean wave energy will complement the Bakun dam in electricity supply and substitute the fossil in the future.</li> <li>• Ocean energy can produce limited electricity, but still can supply the electricity.</li> </ul>
<p>Legal</p> <p>(Deriving authority from, or founded on law.)</p>	<ul style="list-style-type: none"> <li>• Renewable energy act 2011 (act 725)</li> <li>• In this act provided guidance and legislation to use renewable energy in Malaysia.</li> </ul>
<p>Economical</p> <p>(Refer to operating with little waste or at a saving in order to gain efficiency resource consumption)</p>	<ul style="list-style-type: none"> <li>• Opportunity of occupation.</li> <li>• Generating wealth to the institution that develops the ocean wave energy.</li> </ul>

Thus, technical criteria and environmental factors were developed in order to support the government in enabling the ocean energy at Kuching, Sarawak coast in the future. Once the ocean energy is implemented, all the residents over Sarawak would benefit by it.

### **3.0 Research methodology**

#### **3.1 Research Design**

According to Carriger (2000), research design is the strategy, plan, and structure in conducting a research project. The plan is the overall scheme or program of the research. It includes an outline of what the researcher will do from finding the operational implications to the final analysis of data. A structure is the framework, organization or configuration of the relation between varieties of research. A research design expresses both the structure of the research problem and the plan of investigation used to obtain concrete evidence in relation of the problem. In other words, research design can be thought of as the structure of research- it is the “glue” that holds all the elements in the research project together (Trochim, 2006). The research design for the present study was exploratory-based because ocean wave energy is a new technology that needs to be explored to gain an in-depth understanding on it.

According to Rowley (2002), a research design is the logic that links the data to be collected and the conclusions to be drawn to the initial questions of a study; it measures coherence. The study produces a blueprint which includes experiments, interview, analysis record, survey, or some combination of these. However, the present study utilized a case study and a survey through questionnaires and interview sessions to gauge an in-depth understanding on the transition from fossil to renewable energy: application of ocean energy in Sarawak, Malaysia to power electrical grid.

The present study utilized qualitative and quantitative method through the following stages:

- Firstly, the South China Sea and its surrounding coastal area of Sarawak were chosen as the location of investigation. Relevant information was collected from selected samples through qualitative interviewing method and quantitative survey method to get answers to the research questions.
- Secondly, a framework was set up to specify the relationship among the variables.
- Thirdly, the blueprint that outlines each procedure from the beginning to the end of the data analysis was set up.

### **3.2 Mixed Method**

This case study in South China Sea nearby Sarawak area was conducted by implementing mixed method. According to Tashakkori (2003), mixed method research studies use qualitative and quantitative data collection and analysis technique in either parallel or sequential manner. However mixed method research may use quantitative and qualitative research equally or unequally (Creswell and Plano Clark 2007). In this mixed method, the significant data between qualitative research and quantitative research were highlighted.

The significant data play very important role so that the relationship among the variables can be determined. Thus, mixed method was selected as the method to achieve the research objective and answer the research questions. First of all, selected engineers from the higher institution of learning were interviewed. Any significant technical information was used to develop the ocean wave energy in Sarawak. Then, a survey through questionnaires was conducted among selected residents in Sarawak. Both of these factors were expected to influence the development of the ocean energy in Sarawak.

### **3.3 Method of Primary Data**

Business Dictionary (2012) states primary data are observed or collected directly from first-hand experience. The research strategy used in the present study was a case study survey. Case study survey is research design in which a survey is administered to a case, either small sample or the entire population of the individual to describe an aspect or characteristic of that population. Questionnaires were distributed to the residents at the beaches of Sarawak. Moreover, an interview survey was also conducted. An interview survey is where the researcher records answer supplied by participants. Questions were asked responses were recorded. The interview sessions were held at the higher institution of learning.

## **4.0 Data analysis and results**

### **4.1 Pilot Test**

Three pilot test were conducted among three respondents to identify problems and discrepancies in the questionnaire and the problems had been amended before the actual survey was conducted.. Few recommendations were obtained to change the words in the questionnaire to enhance readers' understanding. Then, two more pilot tests were conducted to ensure the respondents understand the message. Upon the completion of the pilot tests, an actual survey began.

### **4.2 The Social Acceptance Level**

According to Wustenhagen et.al (2007) social acceptance is a part of the renewable energy technology implementation which was largely being neglected in the 80s when the policy programs

started. Most respondents agree that most part of coastal area in Sarawak face insufficient electricity supply. This fact is also supported in literature (The score of respondents agreement on the insufficient electricity supply is shown in Table 1.2)

The findings showed that most respondents scored on agree. At the same time, the results showed the support for literature that most residents who live in a coastal area in Sarawak face the insufficient electricity supply. Hence, it is high time to propose ocean wave energy implementation in Kuching, Sarawak.

**Table 1.2 : Score on agreement for insufficient Electricity Supply**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.00	3	12.0	12.0	12.0
	3.00	4	16.0	16.0	28.0
	4.00	11	44.0	44.0	72.0
	5.00	7	28.0	28.0	100.0
	Total	25	100.0	100.0	

The percentage of respondents that score agree on the insufficient electricity supply matter was higher, 72 percent. While neutral and disagree scored a low percentage which indicated that not every place in the coastal area of Sarawak faced insufficient electricity supply.

From the analysis, it can be summarized that at present, most residents of Sarawak that live in coastal areas around Kuching faced insufficient electricity supply. This might be due to the fact that the dam that provides electricity to each household cannot supply ample electricity to the coastal area.

## **4.2 New Electricity Source**

The results also showed that most of them scored agree on new sources of electricity needed in the coastal area of Kuching, Sarawak. This question derived to evaluate the assumption of the researcher; insufficient electricity will lead to new source electricity development such as ocean wave energy.

Hence, the residents of Sarawak that lived in the coastal area really needed new source of electricity. Table 1.3 illustrates the score for the need of a new electricity source. 72 percent of the respondents scored agree on the need for alternative energy for electricity. Hence, the existing electricity supply was not sufficient.

**Table 1.3:** Score on the need for a new electricity source

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.00	2	8.0	8.0	8.0
	3.00	5	20.0	20.0	28.0
	4.00	14	56.0	56.0	84.0
	5.00	4	16.0	16.0	100.0
	Total	25	100.0	100.0	

### 4.3 Ocean Wave Energy as Main Electricity Source

Another question asked whether ocean wave energy will become the main electricity source. While 76 per cent agreed with the statement, 20 per cent stated strongly agree and the rest was neutral. Nobody disagreed with the statement. Table 1.4 illustrates the score on whether OWE would become one of the main sources of electricity supply in the future.

**Table 1.4:** OWE as Main Electricity Supply in the Future

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3.00	6	24.0	24.0	24.0
	4.00	14	56.0	56.0	80.0
	5.00	5	20.0	20.0	100.0
	Total	25	100.0	100.0	

### 4.4 Impacts to Marine Activities

Even though positive responses were received from respondents on the OWE adoption in the Sarawak coastal area, the acceptance of environmental impact was also gauged from the respondents. The consideration of the impact of the environment and marine activities had been investigated.

From the Expert 4's views, the criteria to measure the level of social acceptance for marine renewable energy was the technology must be user friendly so that the technology could be easily accepted and must be the bad Impact of OWE to Marine Activities

	N	Minimum	Maximum	Mean	Std. Deviation
Marine	25	2.00	5.00	3.5200	.91833

The analysis showed the mean was 3.52 which indicated the respondents agreed with the statement. The statement is OWE would bring bad impact to the marine activities. Respondents were aware of the impact of marine activities on activities like recreation and fisherman activities.

The respondents acknowledged the impact of the devices to the marine activities. However, the score on their consideration of the environmental impact showed their main desire to obtain sufficient electricity supply. Table 1.6 showed the consideration of environmental impact.

**Table 1.6:** Consideration of Environmental Impact

	N	Minimum	Maximum	Mean	Std. Deviation
Impact	25	2.00	5.00	3.6000	.86603

From the analysis, the mean for the environmental impact consideration was 3.6 which show most of the respondents agreed with the statement that “the impact of the environment could be considered as long as OWE brings benefit to social lives”. The respondents agreed with the statement because they really needed the sufficient energy even to the extent of sacrificing the environment around them. The need is vital and they considered sacrificing some environmental factors so that they could enjoy the benefit. The sufficient electricity supply was their major concern. However, to understand more about the distraction of marine activities, another statement was issued; fisherman will go against the implementation of OWE. The result of the survey is shown in Table 1.7 below.

**Table 1.7:** Fisherman Against the OWE Implementation

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 2.00	7	28.0	28.0	28.0
3.00	14	56.0	56.0	84.0
4.00	4	16.0	16.0	100.0
Total	25	100.0	100.0	

From the analysis, 72 per cent of respondents scored neutral for this statement. Then, only few respondents agreed with that statement and the rest scored disagree which indicated that the fishermen will not go against the OWE implementation.

The OWE would affect fishermen because after the OWE implementation, the area for fisherman to fish would be reduced which would reduce their income. They must also be aware of the international borders. They cannot go out from the Malaysia border or they will be accused as invaders to the nearby countries.





**Figure 1:** Borders of East Asia Countries

*Source: www.menasborders.com (2009)*

Figure 1 shows the sea border of Malaysia. A fisherman is forbidden to go out of the border of the country to avoid from being accused as an invader. However, the farm of the OWE would not consume a large place of the marine activities. Hence, they can still do their routine as usual.

The researcher anticipates that the respondents do not involve in the marine activities before and caused them to feel neutral. The researcher made this speculation because there are respondents those supports OWEs implementation by indicating the disagreement with the statement that they feel that the fisherman will not go against the implementation of OWE.

#### **4.5 Job Opportunity**

Besides providing sufficient electricity supply, OWE also provides a job opportunity. The researcher has devised a statement; job opportunity from OWE development would attract the social acceptance. Table 1.8 shows the job opportunity attraction.

**Table 1.8:** Job Opportunity Attraction

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 3.00	6	24.0	24.0	24.0
4.00	17	68.0	68.0	92.0
5.00	2	8.0	8.0	100.0
Total	25	100.0	100.0	

From the analysis, most respondents agreed with the statement; 76 per cent agreed job opportunity from OWE would attract the social acceptance, implying that the society of Sarawak would accept the OWE if the OWE itself provided job opportunity for them.

The respondents are attracted to job opportunity when the OWE is implemented. The OWE would offer the job such as general officer to help in the management aspects of the OWE. It will reduce the unemployment rate among the residents of Sarawak.

#### **4.6 Importance of Social Acceptance**

Social acceptance is the most important in the OWE development in Kuching, Sarawak. Table 1.9 shows the score on the importance of Social Acceptance in OWE implementation.

**Table 1.9:** The score on the importance of Social Acceptance in OWE Implementation

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 2.00	1	4.0	4.0	4.0
3.00	4	16.0	16.0	20.0
4.00	17	68.0	68.0	88.0
5.00	3	12.0	12.0	100.0
Total	25	100.0	100.0	

From the analysis, 80 per cent agreed with the statement. This analysis can be supported for the importance of social acceptance in influencing the technology adoption.

In general, the social acceptance of the technology that needs to be developed in their area is the most important thing that needs to be highlighted. This is because the technology that is developed would consume their favorite area. Hence, the developer should investigate the acceptance of the society.

#### **4.7 Technical Limitations in Ocean Wave Energy Implementation**

In this section, the technical limitation criteria and their significance are presented.

#### **4.8 Technical Limitations Criteria**

In order to implement the Ocean Wave Energy (OWE), some emerging technical limitations are evaluated. Interview sessions were held to gain the experts' opinion on the limitation. First of all, to determine the limitation, the technical limitation needed to be evaluated.

*"Power quality is the main issues where the electricity that created must be suitable voltage and current to supply to household."*

*Expert 1*

From the Expert 1 opinion, power quality was an important issue that should be highlighted. According to Sankaran (2002), power quality is a set of electrical boundaries that allows a piece of

equipment to function in its intended manner without significant loss of performance or life expectancy. Hence, power quality is one of the criteria that should be emphasized during the implementation of the OWE. This is because at the end, electricity supply is used by the consumer. Thus, power quality should be a prime concern for the developer of the OWE.

*“Energy efficiency also become technical limitation because uncertainties about the output that gained.”*

*Expert 2*

The opinion from Expert 2 described that energy efficiency would become one of the technical limitations because of the uncertainties about the energy efficiency of the OWE. This is because we have not implemented the OWE yet. So the efficiency cannot be measured without the actual OWE. The energy efficiency is an important factor that would be affected by power quality. Without any in-depth research, uncertainties will prevail for OWE is yet to be implemented in Kuching, Sarawak.

However, in the United States and other countries that develop OWE, they have faced less problems about the energy efficiency regarding to the existence of OWE and it is easier for them to make a measurement. They also have an expert in the OWE on their side.

*“The synchronization also becomes one of the issues. The synchronization is the output produce from the technology must be sustained and the power generation must be equal.”*

*Expert 3*

The Expert 3 stated that synchronization of the OWE was one of the criteria that should be emphasized in OWE implementation. The synchronization between the outputs produced from the technology must be sustained and the power generation should be equal, implying that the power generation should be equal to the power generation that was produced by the OWE and the existing fossil fuelled power generation as well. This matter is very important for customer satisfaction. On the other hand, the power that provides electricity supply must be not too high or too low than the standard electricity supply to household. This is because too high will cause a short circuit while too low will affect the efficiency of electricity supply

*“Asset management is one of the issues because the device conditions need to be monitored to get sustainable output and plant design is also including the criteria of limitation.”*

*Expert 1*

In the Expert 1's opinion, asset management was also one of the criteria of the technical limitation of the OWE. The asset management was important because the management of the OWE should always monitor the device condition in order to get sustainable output. On the other hand, he also stated that plant design should be included in the criteria of the limitation.

In short, asset management and plant design are important criteria to be heeded. Plant design and asset management are related to each other because the asset management is considered by the plant design. This is because the engineering activity is supported by the asset management.

*“Storage problem would also be the problem to implementation of the OWE because it will involve large funding”*

*Expert 4*

Expert 4 stated that the storage of the energy from the device of OWE would become a problem because it would involve large funding to develop it. The storage refers to the storage of the energy before it is sent to electrical grid. The storage functions like a battery. After the device collected the energy, it would be saved into the storage. However, the development of the storage would consume large funding. In the researcher opinion, the storage would consume large funding because the organizer needs to employ and hire few expertise from other countries who have developed the OWE before. Their expertise is needed because our country lacks of expert on the OWE.

All of these criteria of limitation have been highlighted by the experts in the discussion. Even though funding is not one of the technical limitations, without funding, the implementation might not be realized. These technical limitation criteria need to be evaluated prior to the OWE implementation. The implementation cannot succeed without determination to overcome the limitation.

#### 4.9 Most Significant Limitation

After gaining insights on the technical criteria, the influence of the limitations in OWE implementation was determined. This information is needed so that the solution to overcome the limitations.

*“The different of the wave strength would affect to inconsistent of the output produced. The different of the output would damage the electrical grid.”*

Expert 4

The wave strength was the major problem. However, with the geographical advantage of the South China Sea which is next to a sea/ocean provides such a convenience for ocean energy harvest. The wind flows continuously without any barrier of land to generate waves as shown in Figure 2.



Figure 2: South China Sea

Source: [www.feng.unimas.my](http://www.feng.unimas.my) (2013)

#### 5.0 Innovative solution to implement Ocean Wave Energy

After evaluating the weaknesses and the technical limitations, an innovative solution that can improve the development of the ocean wave energy is ascertained. Engineers should produce the small scale version of OWE device to harvest the electricity from wave. Initially, the device is big in size and produces huge energy. However, reducing the scale of the device is a good way to overcome the

weakness of the ocean wave. . To attain the energy supply which is similar as the original version, the small scale version should be built in several numbers until it can produce the electricity supply similar to that of the original version.

## **6.0 Conclusion**

In conclusion, most respondents agree to develop ocean wave energy. Most of them acknowledge the benefits derived from the ocean wave energy and aware of the OWE potential for future use. Some of the benefits include reducing the pollution effect of the fossil fuel burning, complementing the Bakun dam and substituting the fossil fuels usage in generating electricity. Moreover, the implementation of OWE will create new job opportunities to curb unemployment issues in Sarawak. On the other hand, technical limitation exist in the implementation of OWE. The criteria that have been discovered during the in-depth interview sessions with the experts are the power quality, the uncertainties of the energy efficiency, synchronization of electricity supply of the fossil fuel usage and OWE, asset management, OWE plant design and storage problems. Which need to be considered in order to enhance the implementation of OWE. This study will benefit the energy sectors in Malaysia as our government is obviously encouraging industries to conserve the use of fossil fuels. In future, more research on the OWE should be conducted in other locations at the off shore area such as Kelantan, Terengganu, Pahang, Negeri Sembilan and Johor.

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